ISAAC

THE
APPLE-BASED
LABORATORY
COMPUTER
SYSTEM

Cyborg

ISAAC

HARDWARE REFERENCE MANUAL

Cyborg®

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ISAAC 91A HARDWARE REFERENCE MANUAL

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ISAAC

CHAPTER 1

INTRODUCTION

CHAPTER 1: INTRODUCTION

Cyborg's ISAAC model 91A is a flexible, high-speed, multi-channel data acquisition and control system designed to be used with the Apple II microcomputer. It allows the Apple easy access to a variety of analog and binary (digital) signals via a number of different Input/Output channels. Input and output signal parameters are most often established under software control, but there are also several hardware reconfiguration options which may be used to modify I/O signals.

The 91A ISAAC unit is only one part of a larger system that includes LabSoft, Cyborg's powerful extension of Applesoft BASIC, as well as the Apple II and its associated storage and display peripherals. It's a sophisticated system, and like any comparable system, there's a fairly large body of information that the user may need to know at one time or another. Of course, not everybody will need to know everything, and we have written the system documentation with that fact in mind. We decided to divide the documentation into four volumes (in addition to the excellent documentation that comes with the Apple II, which we admire, but unfortunately can't take credit for) so that every user can have easy access to the information needed and not have to wade through volumes of detail in order to find it.

The first step in this process was to divide the reference documentation into two manuals: the LabSoft Reference Manual (Software), and the ISAAC 91A Hardware Reference Manual (this manual). In addition, an ISAAC/LabSoft User's Guide covering aspects of both manuals, and a Quick Reference Guide to LabSoft were written. Unless you are already familiar with the techniques of data acquisition and control, the User's Guide is the best place to start. In addition to telling you how to set up your system and put it into operation, the User's Guide will introduce you to LabSoft, and to the basic techniques of data acquisition and control.

This manual is a hardware reference manual, and as

such covers a good deal of ground. Everything from setting up the system to designing your own custom hardware devices is dealt with here. Since different topics usually involve different levels of user sophistication, we have divided the information in this manual into two levels. After you've read the introductory material in the next two chapters, you'll know more about whether you need to continue on into the more advanced material. If you do, you'll find a chapter on each of ISAAC's on-board devices, a chapter on hardware reconfiguration options (not at all as difficult as it may sound) and several appendices.

Although this manual can serve both the novice and the experienced ISAAC user, please keep in mind that this is a reference manual and not a tutorial. We assume (at least in some places) that you have a working knowledge of both data acquisition and modern electronic data transmission devices. You should also be familiar with Digital Sampling Theory, A/D and D/A converter/multiplexer operation, parallel I/O handshaking and TTL circuitry. This knowledge base is by no means essential to successful operation of the ISAAC/LabSoft/Apple system, but it will certainly increase your ability to make use of the system.

NOTE The very first thing you should do is read the documentation that comes with the Apple II. Not only is it interesting ... it's sometimes even funny. And it will give you the background information necessary to understand ISAAC and LabSoft.

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CHAPTER 2
Setting Up The System

CHAPTER 2

SETTING UP THE SYSTEM

CHAPTER 2: SETTING UP THE SYSTEM

System setup instructions are included in the ISAAC/ LabSoft User's Guide and are repeated here mainly as a matter of convenience. It is assumed that the user has already set up the host computer (an Apple II Plus with at least 48K of RAM, or any Apple II with an optional Language Card), and is familiar with its operation.

2.1 Environmental And Power Requirements

ISAAC will operate in any environment that the Apple will. Extremes of temperature and humidity are to be avoided, as are areas where there's apt to be much electromagnetic interference. The ISAAC/LabSoft/Apple system is fairly portable, but it would probably be best to set it up on either a wheeled cart or else as close as possible to the area where it is going to be used. The whole system (including the optional printer) will fit nicely into a two by four foot area and will typically draw less than 5 amps at 110-120 Volts. We recommend using a dedicated line to power the ISAAC/Apple system (or any computer system). Any additional cost incurred will be more than offset by the peace of mind (and glitch-free operation) that comes with a dedicated power supply.

2.2 A Note About Signal Cabling

In general, it isn't a good idea to run signals to and from the system over distances greater than twenty-five feet. This is especially true of low-level analog signals, and can apply to parallel binary signals as well. Serial binary communications, while relatively slow, are the least susceptible to being garbled by noise. We recommend exclusive use of shielded cable for all analog signals, although for short-distance cabling of high-level analog signals, a twisted pair will suffice.

In environments where there is apt to be a high level of ambient RF noise, it is particularly important to observe these cautions.

2.3 Hardware Setup

Turn system off power before setting up or reconfiguring any part of the ISAAC/LabSoft/Apple system.

A. **REMOVE THE INTERFACE CARD AND CABLES FROM THEIR BOX.** The ISAAC/Apple Interface Card, it's associated cables, and the battery pack which provides backup power for the real-time clock are packed in the smaller of the two boxes you'll see when you open ISAAC's shipping container. **HANDLE THIS ASSEMBLY CAREFULLY.** It's a fairly delicate piece of electronic equipment and should be treated like one. Take care not to contaminate or otherwise damage the pins. Unwrap the cables from around the card. They are already plugged in to the connectors on the card and should be left that way.

B. **REMOVE THE BATTERY PACK FROM THE CARD/CABLE BOX.** The battery pack is supplied with two high-quality **ALKALINE BATTERIES** which should easily keep ISAAC's real-time clock running for at least a year. These batteries should only be replaced with similar Alkaline Batteries. Cyborg does not recommend the use of Carbon-Zinc batteries with any of its equipment, or anything more sophisticated than a flashlight.

C. **REMOVE THE ISAAC UNIT FROM THE BOX.** Slide it out. Remove the two foam shipping cushions. Open the plastic bag and take out your ISAAC. **THE TEST KIT IS TAPED TO THE BOTTOM OF THE ISAAC CHASSIS.** Remove it and set it aside for now.

D. **CHECK THE PACKING MATERIAL CAREFULLY.** Be sure there's nothing you have overlooked. Then **SAVE ALL PACKING MATERIAL.** If ISAAC ever has to be shipped, it should be repacked and shipped in this container.

E. **PLUG THE INTERFACE CARD INTO APPLE PERIPHERAL SLOT NUMBER THREE.** (See Fig. 1, next page) This is the slot where LabSoft "expects" to find this card. If you already have a card in that slot and it can't be relocated, see the references to LabSoft's & SLOT# command in this

manual and the LabSoft Reference Manual. **FOLD THE CABLES AS SHOWN IN FIGURE 1 AND RUN THEM BESIDE THE CARD AND OUT THROUGH THE VERTICAL OPENING AT THE BACK OF THE APPLE.** If you have a card in Slot #4, it would be easier to temporarily remove it before installing the ISAAC/Apple Interface Card.

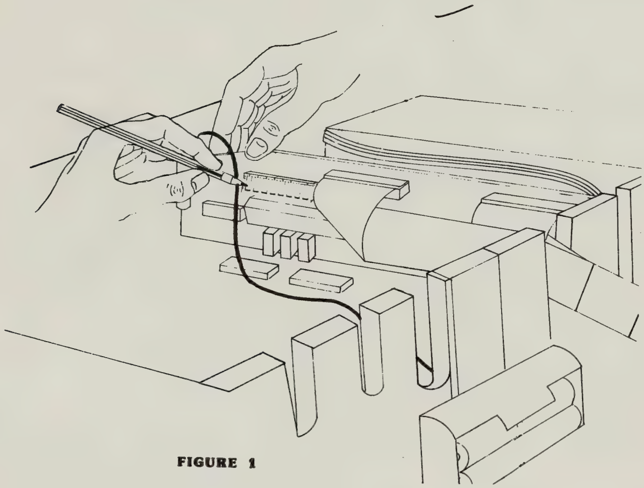

FIGURE 1

F. **HANG THE BATTERY PACK OVER THE BACK OF THE APPLE. CONNECT THE PLUG TO JACK J3 ON THE INTERFACE CARD.** The drawing above shows the battery pack in place. The lead may be run in through the same vertical opening used by the ISAAC/Apple Interface Cable.

G. **CONNECT THE OTHER END OF THE ISAAC/APPLE CABLE TO CONNECTORS E1 AND E2 AT THE REAR OF ISAAC'S CHASSIS.** (See Fig. 2, next page) Each of these connectors is keyed to fit only the correct plug. Properly connected, the cables will be at the lower edge of the connectors.

At this point, all the necessary connections between ISAAC and the Apple have been made. The hardware portion of the system is complete.

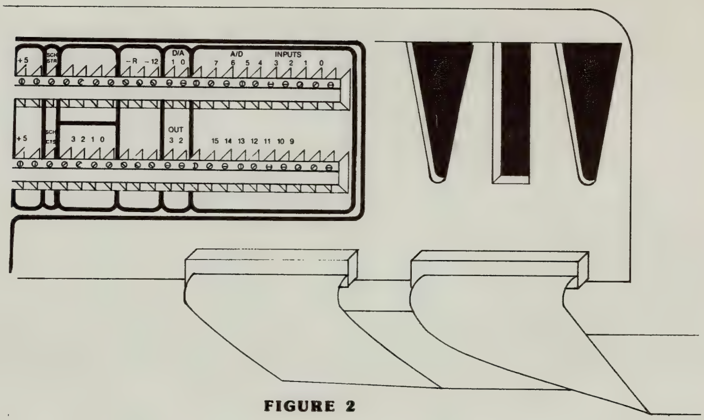

FIGURE 2

2.4 A Note About the Distribution Panel

Unless you are going to use Mass Terminated Interfacing Cable to hard-wire your system into some fairly permanent situation, you will be making all of ISAAC's connections to the real world (by which we mean anything other than the system and its various storage and display devices) through the **DISTRIBUTION PANEL.**

The distribution panel is a green P.C. card with two fifty-pin edge connectors on one side and ninty-six screw terminals on the other. It plugs into the two leftmost connectors (connectors E3 and E4) on the back of ISAAC's chassis and performs no function other than making the pins of E3 and E4 available in a more convenient form, distributing their functions among the various screw terminals.

Each screw terminal is labeled, and as you go through this manual and the rest of the ISAAC documentation, these labels will begin to mean something to you. The screw terminals will accept many different sizes and types of wire, but we recommend stranded cable between 17 and 22 gauge, stripped 1/4 inch and tinned.

Loosen the terminal clamp by giving the screw a few turns counterclockwise, insert the stripped end of the wire, and secure it by tightening the clamp with a few clockwise turns of the screw. Ideally, there should be a little uninsulated wire visible outside the screw terminal, so that you know the clamp is making good contact with the stripped wire and not the insulation. Unless the screw terminal has been firmly tightened down on a suitable conductor, connections to the distribution panel will be dubious at best.

NOTE The screw itself is not a valid electrical connection. Attempts to input/output signals by touching wires, probes, etc. to these screws will probably not work and are definitely not recommended.

ALWAYS TURN POWER OFF USING ISAAC'S FRONT PANEL "POWER" SWITCH) BEFORE MAKING OR BREAKING CONNECTIONS TO THE TEST PANEL. SWITCHING ISAAC OFF IN THIS WAY MAY AFFECT THE PROGRAMS IN MEMORY.

Although ISAAC hardware is designed to withstand momentary overloads, it's conceivable that a wrong connection with power on could result in hardware damage.

Care should be taken when wiring the distribution panel. Before turning on ISAAC's power, recheck all inputs, outputs and grounds to be sure they are firmly and properly connected. As always, wherever electrical wiring is being done, neatness counts! Use of uninsulated wire for any distribution panel connection or jumper is not recommended.

Although it is shipped as part of the ISAAC unit, the distribution panel is removable. To remove the distribution panel, slide the snap-latch fastenings to the left and unplug the panel from connectors E3 and E4. In many cases it will be convenient to order an extra panel or two (Cyborg part # 800-061)

and wire each one to a different external setup.

2.5 A Note About Hard-wired Setups

Certain applications may lend themselves to hard-wiring with optional Mass Terminated Cable (Cyborg part #800-059) . This cable plugs into connectors E3 and E4, and may be terminated by the user in any way desired (i.e. edge connectors, clips, tinned wires, etc.). All the above cautions concerning the distribution panel (as well as those concerning cabling in general) should be observed when using Mass Terminated Cable.

2.6 A Quick Functional Check

The easiest way to ascertain whether the ISAAC/Lab-Soft/Apple system is properly connected is to:

1. Boot the LabSoft Master Disk.

2. Type "NEW" to clear the LabSoft Disk's Hello program.

3. Be sure ISAAC power is on.

4. Type & BUZZ

5. When you hit return, ISAAC should emit a brief (.1 second) buzz that is not at all like the Apple's beep. This indicates that LabSoft has been loaded and initialized, and that the hardware/software interface is complete.

If instead, the Apple beeps and returns a ?SYNTAX ERROR message, re-check all the setup procedures above and try again. A ?SYNTAX ERROR returned after a known-syntactically-correct LabSoft command generally indicates that LabSoft has not been properly loaded and initiated.

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CHAPTER 3

AN OVERVIEW OF ISAAC HARDWARE

CHAPTER 3: AN OVERVIEW OF ISAAC HARDWARE

In the ISAAC/LabSoft User's Guide and the LabSoft Reference Manual we have generally referred to ISAAC as part of a system (the ISAAC/LabSoft/Apple system). In addition, the 91A ISAAC is itself a system; a configuration of devices, both implemented and non-implemented, that work separately and together to perform the assorted I/O functions necessary to sophisticated data acquisition and control. Before we get into any one device too deeply, we should take a few pages here to present a broad overview of the hardware system. Once you've read this chapter, you should have a better idea of which device types you want to study in greater detail. There are three major components in the ISAAC unit: the Main Board, the ISAAC/Apple Interface Card, and the I/O distribution panel.

3.1 The ISAAC 91A Main Board

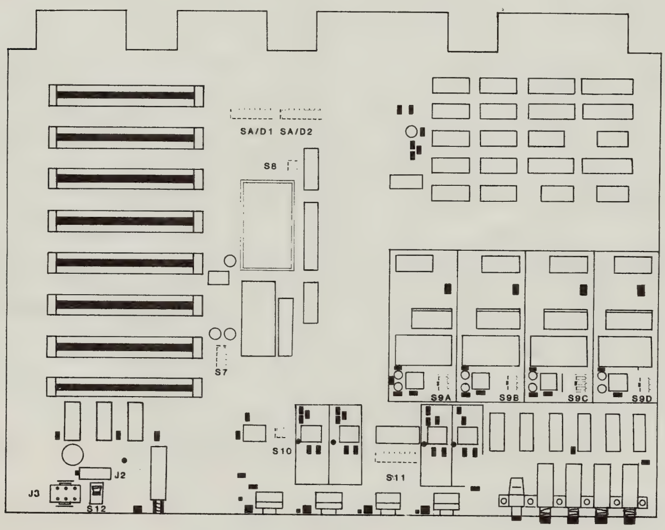

FIGURE 3

Most of what you'll see if you remove the cover of

an ISAAC is the main board (see Fig. 3, previous page). This is the P.C. card that contains all of the I/O circuitry, as well as the eight expansion slots. As shipped, ISAAC consists of four devices. Three of these (the Analog, Binary, and Counter devices) reside on the main board. The fourth (the Timer/Real-Time Clock) is located on the ISAAC/Apple Interface Card. In addition, any device which supports ISAAC's internal communication protocol may be plugged into one of these expansion connectors and accessed by LabSoft in the same manner as ISAAC's on-board (default) devices.

3.2 The ISAAC/Apple Interface Card

This card plugs into a peripheral slot (usually Slot #3) on the Apple II main board. It is the hardware interface between ISAAC and the Apple, in the same way that LabSoft is the software interface. All ISAAC/Apple communication is routed through the Interface Card. The card contains two bi-directional ports; each is one word (two bytes) wide. The Apple sends data and commands to ISAAC, and ISAAC sends data and status information back to the Apple through these ports. In normal applications, the ISAAC main board also gets its power (from the Apple) via this card.

3.3 The ISAAC I/O Distribution Panel

This panel (essentially a componentless P.C. card) plugs into the pin connectors found on the back of the ISAAC chassis. There are 96 screw terminal connectors arranged in two rows on the outer surface (the component side) of this panel. Unless you choose to hard-wire your ISAAC into some fairly permanent setup (using the optional pair of mass-terminated cables, Cyborg part #800-059) all connections between the ISAAC/LabSoft/Apple system and the rest of the world will be made through this panel and its screw terminals.

The panel itself is secured to the ISAAC chassis by two snap-slide fasteners, and can be easily removed. In many cases, you may want to order several Distribution Panels and wire each one for a different application. Whether or not you choose to do this will depend largely on the complexity of your interface wiring. Simple changes in the number or location of wires at the distribution panel

can be made in a few minutes. Major re-wiring can take quite a bit longer. Should you need to order additional distribution panel(s), specify Cyborg part #800-061.

3.4 ISAAC 91A Hardware Device Map

The on-board devices and their functions, and the expansion device slots are numbered as shown on the device map (Fig. 4) below. Expansion devices should emulate these functions as closely as possible in order to be accessed efficiently by LabSoft.

DEVICE #	DEVICE TYPE
0	EXPANSION DEVICE # 0
1	EXPANSION DEVICE # 1
2	EXPANSION DEVICE # 2
3	EXPANSION DEVICE # 3
4	EXPANSION DEVICE # 4
5	EXPANSION DEVICE # 5
6	EXPANSION DEVICE # 6
7	EXPANSION DEVICE # 7
8	NON-IMPLEMENTED DEVICE
9	NON-IMPLEMENTED DEVICE
10	NON-IMPLEMENTED DEVICE
11	NON-IMPLEMENTED DEVICE
12	DEFAULT ANALOG I/O
13	DEFAULT BINARY I/O
14	DEFAULT COUNTER
15	DEFAULT TIMER/CLOCK

FIGURE 4

The expansion slots on the ISAAC main board are designed to accept various bus-compatible devices. For those interested in adding such devices to the basic ISAAC, general interface and communication information may be found in Appendix X of this manual. A brief description of each of the onboard (default) devices follows and each also has a chapter to itself later in this manual. Specifications of these devices are covered in their respective chapters may be used as benchmarks for expansion devices.

WARNING! DO NOT PLUG ANY APPLE PERIPHERAL CARD INTO ANY ISAAC EXPANSION SLOT. THE PINOUTS ARE INCOMPATIBLE AND FATAL HARDWARE DAMAGE WILL OCCUR!

3.5 The Analog I/O Device

This device provides 16 channels of single-ended (or 8 channels of true differential) 12-bit A/D input as well as four channels of 12-bit D/A output.

3.6 The Binary I/O Device

This device provides a one word (16-bit) parallel binary output bus with tristate-enabling capabilities. It also provides a one word (16-bit) parallel binary input bus and four channels of latching Schmitt trigger input (front panel or externally-set threshold). Bus latching and full handshaking capabilities are implemented with all Binary I/O device functions.

3.7 The Counter Device

This device provides a 16-bit externally clocked count-up counter, with an eight channel MUX. ISAAC's audio beeper/buzzer hardware also resides at this location, although it is not dependent on the counter for any beep/buzz functions.

3.8 The Timer/Real-Time Clock Device

This device is located on the ISAAC/Apple interface card, not on the ISAAC main board. It provides a sixteen bit count up timer and a real-time clock with battery backup.

3.9 The Power Supply and Reference Voltage Subsystem

Although it is not an I/O device, this subsystem provides both power and reference voltages to all other devices. In the basic ISAAC system, power is supplied by the Apple II power supply via the ISAAC/Apple Interface Card. ISAAC may be powered by an optional external power supply (Cyborg part #261-031) if more current or greater voltage range is required. The Apple II supply furnishes +/-12 Volts, which is adequate for an analog signal range up to +/-5 Volts for all analog devices. The optional external power supply provides +/-15

Volts, which increases the analog signal range to +/-10 Volts.

This subsystem also provides precision voltage references for A/D, D/A, Schmitt trigger, and external device use. These references, which are derived from a monolithic bandgap device, are extremely stable and accurate.

More detailed descriptions of the functions provided by each of the on-board devices will be presented in the following chapters. One particularly interesting aspect of ISAAC device design is the amount of built-in configurability. Many of the requirements normally associated with the interfacing of data acquisition devices are completely user-configurable in the ISAAC system.

3.10 User Configuration Options

There are two types of configuration options available to the user: software-programmable and switch-programmable.

A. **Software Programmable Configuration:** The simplest method of system reconfiguration involves only software. Simple processes such as determining which bits of a binary input word are significant are directly programmable from the LabSoft data acquisition language.

B. **Switch Programmable Configuration:** Some aspects of ISAAC device functions can be configured by means of DIP switches on the ISAAC main board. One of these features is the threshold source for the Schmitt trigger inputs. With the appropriate switch in one position, the threshold level is determined by one of ISAAC's front panel controls. With the switch in another position, the threshold level can be determined by an external device. Many similar binary-type configurations are provided for in this manner.

The "nuts-and-bolts" of user configuration will be dealt with in great detail in Chapter 8. The next three chapters will cover the Analog, Binary, and Counter devices in detail.

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CHAPTER 4

THE ANALOG I/O DEVICE

CHAPTER 4: The Analog I/O Device

ISAAC's on-board analog device consists of two subsystems: one to handle analog signal input (the A/D subsystem) and another to handle analog signal output (the D/A subsystem).

The A/D subsystem reads (inputs) analog signals from the real world (any external device which generates analog voltages) and converts them to digital values usable by the ISAAC/LabSoft/Apple system. The A/D converter resolves to 12 binary bits (by successive approximation) and has a nominal conversion time of 25 microseconds. The precision analog MUX provides up to 16 channels of single-ended (ground referenced) input or up to 8 channels of true differential input, with a 100 microseconds settling time. There is a precision gain stage, switchable for gains of X1 or X10, between the A/D converter and the A/D MUX. In applications dealing with very low-level signals, a gain of X10 will allow greater signal resolution, although any noise associated with the signal will also be amplified. Signal averaging (using LabSoft's & ASUM command) is one of the easiest ways to optimize signal/noise ratios.

The D/A subsystem consists of four discrete 12-bit D/A converters, each having a settling time of 5 microseconds. This subsystem takes binary values generated by the Apple and converts them to analog values suitable for output to any voltage-driven device in the real world.

4.1 The A/D Subsystem

Analog input is handled by the analog device's A/D subsystem. This subsystem is set up at the factory in the following manner.

Up to 16 analog channels are available. As shipped, the analog MUX is configured to handle up to 16 single-ended inputs, but the user has the option to reconfigure the system to handle as many as 8 true differential inputs instead. The input voltage range of the MUX depends on the range of

ISAAC's reference voltages, and on the positions of the A/D input DIP switches. As it comes from the factory, the A/D input accepts inputs in the range of -5 to +5 Volts.

With the MUX configured in the single-ended mode, the following pinouts (found on connector E3 at the rear of ISAAC's chassis) apply:

Channel #	Pin #
0	1
1	3
2	5
3	7
4	9
5	11
6	13
7	15
8	2
9	4
10	6
11	8
12	10
13	12
14	14
15	16

In the true differential mode, the following pinouts apply (Pin #s are HIGH side & LOW side):

Channel #	Pins #
0	1 & 2
1	3 & 4
2	5 & 6
3	7 & 8
4	9 & 10
5	11 & 12
6	13 & 14
7	15 & 16

The specifications for the A/D converter and A/D MUX are as follows:

Resolution: 12 bits binary

Input impedance(gain = X1): < 150 pf,
< 100 MegOhms

Input impedance (gain = X10): < 150 pf,
< 100 K Ohms

Maximum input voltage (gain = X1): +/- ISAAC reference voltage.

Accuracy: +/-.05% of full scale at +/-5 milliVolts

Differential linearity: +/-.025% of full scale.

Channel acquisition time: 100 microseconds.

A/D conversion time: 25 microseconds.

Temperature coefficient: +/-75 PPM/degree Celsius.

Common mode rejection (differential mode): 70 decibels.

Throughput rate: 25 kiloHertz.

The following functions of this device may be reconfigured by the user (see Chapter 8 of this manual for further details).

1. Input voltage range

2. A/D voltage range (MUX to A/D gain stage)

3. MUX mode (single-ended or differential)

4.2 Using the A/D Subsystem

The A/D converter generates a 12-bit binary code based on the voltage measured at its input. An input of -5 Volts generates a code consisting of all zeroes (0000 0000 0000). An input of 0 Volts generates a code of a single "one" followed by eleven zeroes (1000 0000 0000). An input of +4.997 Volts generates a code of all ones (1111 1111 1111).

The A/D converter can be operated in either a single-ended or a true differential mode. In the single-ended mode the voltage between the selected input (one of 16) and signal ground is measured and converted to a 12-bit binary value. In the differential mode, the voltage between the selected

pair of inputs (one of 8 pairs) is measured and converted to a 12-bit binary value. The single-ended mode allows twice as many inputs to be measured, but the differential mode provides better noise rejection. This is particularly important for low-level signals. See Chapter 8 for complete instructions on reconfiguring the MUX mode for true differential inputs.

In the single-ended mode, any external device used as the source of an input voltage must have its signal ground tied directly to ISAAC's signal ground. Only a very low-level electrical current should ever be present in ISAAC's signal ground wire. Currents of even a few milliAmperes may cause significant voltage drop errors induced by system ground wiring resistances. Shielded cable is recommended, particularly for devices which are located more than a short distance from ISAAC. The A/D input should be connected to the center conductor, and the signal ground should be connected to the shield. In general, all analog signals should be shielded.

When the differential input mode is used, the A/D converter measures the difference in voltage between a pair of input wires (the "high" and "low" inputs). Neither of these wires need be tied to the ISAAC signal ground, but signals present on either wire must remain within the maximum input capability of the A/D converter (+/-5 Volts in ISAAC as shipped). This can be accomplished by connecting the ISAAC signal ground to a point in the external device (the device's signal ground is most often used). ISAAC will generate the A/D reading by subtracting the voltage on the "low" input from that of the "high" input. If the "low" input is more positive, ISAAC will read a negative voltage. The best way to shield a differential input is to use two-conductor shielded cable, with the shield connected to ISAAC's signal ground and the signal carried on the two conductors.

NOTE If any of the four "READ SCHMITT THRESHOLD" switches on the ISAAC front panel are pushed in, A/D channel 7 (and 15 if the differential mode is in effect) will be connected to the appropriate Schmitt threshold voltage and will not respond to normal input.

4.3 Specifications of the D/A Subsystem

All analog output is handled by the analog device's D/A subsystem. This subsystem has four discrete 12-bit D/A converters available, each with a 5 microsecond settling time. Their D/A output ranges depend on ISAAC's reference voltage (+/- 5 Volts as shipped) and on the positions of the D/A output DIP switches. The D/A outputs are available on the distribution panel, or directly from pins located on connector E3 on the rear of ISAAC's chassis (see chart below).

D/A Channel #	Pin #
0	21
1	23
2	22
3	24

Specifications for each D/A output are as follows:

Resolution: 12-bit binary

Output current: +/-5 milliAmps

Output capacitive load: < 1000 pF

Accuracy: +/-.05% of full scale +/-5 milliVolts

Differential nonlinearity: < +/-.025% of full scale.

Settling time: < 5 microseconds to < 2% of full scale.

Overshoot: < 2% full scale

Temperature coefficient: +/-50 PPM/degree Celsius

The Output voltage range function of this device may be reconfigured by the user (see Chapter 8 for full details).

4.4 Using the D/A Subsystem

ISAAC has four independent, software-controlled output voltages. As shipped, each output has a range of -5 Volts to +5 Volts with respect to

signal ground. A 12-bit binary code of all zeroes (0000 0000 0000) sets the output to -5 volts, a code of a leading "one" followed by eleven zeroes (1000 0000 0000) sets the output to 0 volts, while a code of all ones (1111 1111 1111) sets out +4.997 Volts.

These outputs can drive cables of up to 1000 pico-Farads capacitance at currents of up to 5 milliAmperes. Higher loads may cause static or dynamic specifications to be exceeded. As noted earlier, the use of shielded cable is strongly advised where analog signals (and long distances) are involved.

Since the D/A outputs respond very quickly to software commands, they can be used to generate a variety of program-controlled signals. These signals can, in turn, be used to perform display and/or control functions, or even rerouted back into the system as software-controlled input.

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CHAPTER 5

THE BINARY I/O DEVICE

CHAPTER 5: THE BINARY I/O DEVICE

ISAAC's on-board Binary Device consists of three subsystems: the binary input subsystem, the binary output subsystem, and the Schmitt trigger susbsystem. Each of these subsystems sends or receives data as binary words. This does not mean, however, that binary data must always be considered as words. The ISAAC/LabSoft/Apple system can easily deal with binary data on a bit by bit basis. It is possible, for instance, when sending a new data word to the binary output device, to change the state of just one bit of that word. When that word is put on the output data bus, only the changed bit will be affected; all other bits will remain in their previous state. Among other things, this feature has the advantage of avoiding unnecessary state transitions and their attendant timing glitches.

The binary input subsystem features a one word (16 bit) wide TTL input bus, complete handshaking via two STROBE input lines and one CLEAR TO SEND output line. In addition, the entire bus may be held (latched) via a HOLD input line.

The Schmitt trigger subsystem features four Schmitt trigger comparator circuits. The triggering threshold for each Schmitt trigger may be set internally via ISAAC front panel mounted controls, or externally via a voltage applied to the appropriate I/O connector pins. When the input to a given trigger exceeds its threshold setting, the trigger is set and latched. Triggers remain latched until read by a LabSoft & TRIGIN command, which releases the latch, allowing the triggers to reset where input has fallen below the threshold value. The state of the Schmitt triggers is input as a four bit binary word, with handshaking provided by one STROBE input, and one CLEAR TO SEND output line.

The binary output subsystem features a one word (16-bit) wide TTL output bus, and complete handshaking via two STROBE output lines, and one CLEAR TO SEND input line. In addition, the entire bus is

externally "tristate-able." As mentioned, data changes involving a single bit will only affect that bit. There are no data bus transitions on unchanged lines.

5.1 Specifications of The Binary Input Subsystem

Binary input is handled by the Binary Device's binary input subsystem. This system uses standard TTL level input devices. The entire binary input bus may be held (latched) at any time, by pulling the HOLD lines low. These and all other data, handshaking, and control lines are normally pulled high (+5V) by internal pull-up resistors. If the HOLD feature is not required, you will not have to make any connections to these lines. Note that there are two HOLD lines for the binary input subsystem: one for each byte of the input data bus. They can be used separately, or tied together to latch the entire bus.

If a handshaking protocol is used in conjunction with binary inputs, the following sequence of events (as diagrammed in Fig. 5) will occur with each transmission:

1. ISAAC sets CLEAR TO SEND (CTS) line high.

2. External device puts new data on the sixteen data input lines.

3. External device sets both STROBE lines high for a minimum of 12 microseconds.

4. The data on the input lines must be valid for a minimum of 50 microseconds from the beginning of the strobe pulse.

5. ISAAC pulls CLEAR TO SEND line low, and inputs the new data from the bus.

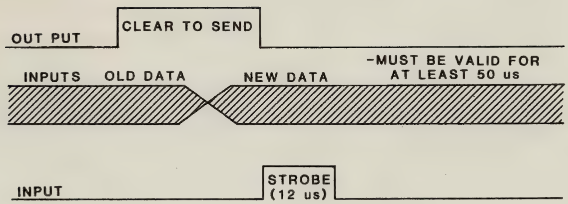

FIGURE 5

NOTE If you are using LabSoft to control ISAAC, you will not have separate STROBE control for each byte. LabSoft will consider EITHER one of the STROBE lines to indicate a data strobe. Under these circumstances, these lines should be tied together and treated as one.

The following pins (found on connector E4 on the rear of ISAAC's chassis) are used by the binary input data bus:

Bit	Pin #
0	17
1	19
2	21
3	23
4	25
5	27
6	29
7	31
8	35
9	37
10	39

Bit	Pin #
11	41
12	43
13	45
14	47
15	49

The following pins (connector E4) are used for the handshaking and control functions of the binary input bus.

Function	Pin #	Direction
Binary Input, STROBE input line, for low order byte (bits 0-7)	11	input
Binary Input, STROBE input line, for high order byte (bits 8-15)	12	input
Binary Input, CLEAR TO SEND output line.	9	output
Binary Input, latch HOLD input line, for low order byte (bits #0-#7)	15	input

Function	Pin #	Direction
Binary Input, latch HOLD input line, for high order byte (bits 8-15)	33	input

The specifications for the binary input subsystem are as follows:

Input voltage/current:

+2 Volts/40 microAmperes (input high)

+0.8 Volts/0.9 milliAmperes (input low)

NOTE Each binary input is a single LS TTL load plus a 10 kilOhm resistor to +5 Volts.

NOTE Data must remain valid for at least 10 nanoseconds after HOLD line is pulled low.

The binary input subsystem cannot be reconfigured by the user.

5.2 Using the Binary Input Subsystem

There are many potential applications for the binary input subsystem. Everything from simply reading the states of external switches to high speed parallel data communication with complete handshaking can be handled by this versatile input unit. The inputs (and handshaking and control outputs) are all TTL level lines, referenced to logic ground. As mentioned in the previous section, all lines are normally pulled up to + 5Volts. This allows for a wide variety of input configurations. Standard (TTL), tristate or open-collector logic may all be easily used. Since the control and handshaking lines are also pulled up, (and since their respective functions are all positive enable) you may choose to implement full, partial, or no handshaking, as your applications dictate.

5.3 Specifications of The Schmitt Trigger Subsystem

This subsystem consists of four Schmitt trigger comparator circuits and associated handshaking logic. It allows up to four voltage levels to be compared with preset thresholds. Each Schmitt trigger circuit can accept a signal voltage within the ISAAC's analog reference voltage range. This is normally set for -5 to +5 Volts, but may be altered as required by the user (see Chapter 8 for details).

In this subsystem, an input level is compared to the Schmitt trigger's threshold setting. When input exceeds that threshold, the trigger is set and a true (1) condition is returned to the appropriate bit of the Schmitt word. Reading the Schmitt word releases the latch function and allows the triggers to reset (to 0) where input has fallen below threshold. Four pushbuttons on ISAAC's front

panel allow you to connect any of the Schmitt triggers' threshold levels to the ISAAC's Analog input channel #7. When this is done, LabSoft can access and display the threshold value for any of the Schmitt triggers.

Each Schmitt trigger circuit's state is represented as one bit of the Schmitt trigger input word. All four devices are read at one time and the binary value returned as its decimal equivalent. The logic used is positive true. This means that for any one trigger circuit, the device is considered to be "on" (setting the corresponding bit of the Schmitt trigger input word to 1) if the incoming signal level exceeds the threshold level.

To prevent oscillation, a small amount of hysteresis is present in each of the comparator circuits.

Full handshaking is available with Schmitt trigger input. Since all handshaking lines are normally pulled up to their logical "true" state, you are free to implement as much handshaking as your communication or sampling protocol requires. If full handshaking is used with Schmitt trigger inputs, the following sequence of events will occur with each sample: (see Fig. 5)

1. ISAAC sets CLEAR TO SEND (CTS) line high.

2. External device is expected to have (or put) valid signals on the Schmitt trigger input lines.

3. External device sets STROBE line high for at least 12 microseconds.

4. The data on the trigger input lines must be valid for a minimum of 50 microseconds from the beginning of the STROBE pulse.

5. ISAAC pulls CLEAR TO SEND (CTS) line low, and inputs the Schmitt triggers' states as a word. Schmitt trigger threshold and input lines are available at the distribution panel, and also at following pins of connector E3.

Schmitt Input #	Pin #
0	39
1	41
2	43
3	45

The following terminals (and pins) can be used to OUTPUT the threshold voltage set by the front panel controls. If the subsystem has been reconfigured to accept an externally set threshold, these become the INPUTS to which this signal should be applied.

Schmitt Threshold#	Pin #
0	40
1	42
2	44
3	46

NOTE All Schmitt trigger inputs and thresholds are referenced to the analog signal ground, pins 17, 18, 19, 20, 49, and 50.

The following handshaking lines (connector E3) may be used;

Function	Pin #	Direction
Schmitt trigger input, STROBE input line.	49	Input
Schmitt trigger input, CLEAR TO SEND output line	47	Output

NOTE Handshaking lines are TTL level lines and must be referenced to the logic ground.

The specifications for the Schmitt trigger input are as follows: (specifications in parentheses reflect the optional X10 range scaling covered in Chapter 8.) [Figures in brackets reflect the use of the optional external +/-15 Volt power supply, see Chapter 8.]

Input voltage range: +/-5 Volts (+/-50 Volts) [+/-100 Volts]

Input impedance: > 10 megOhms (> 100 kilOhms)

Hysteresis: 20 milliVolts [200 milliVolts]

Offset voltage: 15 milliVolts [150 milliVolts]

Response time: 5 microseconds; 50 milliVolts over-drive, 100 milliVolts p-p.

Schmitt threshold control output: +/-5 Volts [+/-10 Volts] at5 milliAmperes.

NOTE Schmitt handshaking inputs and outputs have the same driving and loading specifications as binary handshaking signals.

The following functions of the Schmitt trigger subsystem can be reconfigured by the user (see Chapter 8).

A. Input voltage range

B. Source of threshold level

C. Trigger comparator level ratio

5.4 Using the Schmitt Trigger Subsystem

ISAAC's Schmitt triggers are latching comparators with user-adjustable threshold. Their principal use in data acquisition applications is in determining whether or not an incoming signal has exceeded a certain value (threshold). They are particularly useful in cases where an incoming signal is not TTL level, or is subject to rapid changes in voltage that would make it difficult to quantify by other means.

When such signals are applied to a Schmitt trigger input, the trigger will "fire" when the signal exceeds the preset threshold and latch "on" until the trigger's state is read by LabSoft's & TRIGIN command. & TRIGIN resets the latching function and allows the trigger to clear (go "off", returning a value of 0) if the incoming signal has fallen below the threshold. If the incoming signal is still greater than the threshold value, the trigger will

remain "on", returning a value of 1. Because of the trigger's built-in hysteresis, oscillation of the incoming signal above and below the threshold value will not result in oscillation at the trigger output. In effect, the hysteresis provides the trigger circuit with a certain amount of latitude in determining when the incoming signal has in fact exceeded the threshold.

Threshold values for each of ISAAC's Schmitt triggers can be set in two ways, internally and externally. For each of the four triggers, there is a front panel control (SCHMITT THRESHOLD ADJUST) which may be used for setting the the threshold value. Each of these controls also has a switch (READ SCHMITT THRESHOLD) associated with it which, when depressed, allows the A/D converter to read the threshold setting and make it accessible to LabSoft for screen display. To display a Schmitt threshold value on the screen (or other output device), use LabSoft's & AIN command like this.

```
10 & AIN, (TV) = X, (C#) = 7, (PR)
20 GOTO 10
```

As each READ SCHMITT THRESHOLD button is pressed, the threshold value will appear on the screen. To disconnect all SCHMITT THRESHOLD ADJUST controls from analog input channel 7, press the leftmost of the five READ SCHMITT THRESHOLD switches (OFF). There are also four LED indicators on ISAAC's front panel which are associated with the Schmitt triggers. The LED to the left of the control knob will be lit if the input to that trigger currently exceeds the trigger's threshold value.

NOTE When analog input channel 7 is being used to read a Schmitt threshold level, it is temporarily disconnected from normal input.

In ISAAC as shipped, the range of the Schmitt trigger threshold level is +/-5 Volts. This range can be scaled up by a factor of 10 (to +/-50 Volts) by resetting certain DIP switches on the ISAAC main board. See Chapter 8 of this manual for details.

For normal use, the trigger threshold is set to a known value, then a program is written which allows LabSoft to read the Schmitt trigger states. These states are returned to LabSoft as a 4-bit binary

word, where a 1 indicates that the trigger associated with that bit has been set and a 0 indicates that it has not. Among other things, Schmitt triggers can be used to interface the output of a non-TTL level device to ISAAC, or to detect whether a voltage (one emitted from a temperature sensor, for example) has gone above a particular value.

There are several other ways of setting the trigger threshold voltage control. One way is to connect an external meter to the appropriate Schmitt Threshold terminal (or pin) and read the voltage directly (relative to signal ground). You can also apply a voltage of the desired threshold value to the Schmitt input itself and vary the SCHMITT THRESHOLD ADJUST control until that trigger's LED goes on.

With proper reconfiguration (see Chapter 8) the Schmitt triggers can derive their threshold voltage from an external source. One of the most convenient external sources, strange as it seems, is ISAAC itself. Using LabSoft's & AOUT command, it is possible to specify a threshold voltage very precisely. That voltage can then be routed (with a jumper wire) from the D/A output to the Schmitt threshold input, providing the necessary switch settings have been made. If you know the threshold value you want, this is one of the easiest and most convenient ways of setting it.

Another reconfiguration option allows both the Schmitt input and Schmitt threshold to be connected to changing external signals. In this mode the Schmitt device will indicate whether one of the signal voltages has gone higher than the other.

When a Schmitt trigger is not being used, the potentiometer-controlled threshold voltage is available at the appropriate Schmitt threshold terminal (or pin) for external use. This voltage can be varied, using the SCHMITT THRESHOLD ADJUST control, between -5 Volts and +5 Volts. The output will drive up to a 5 milliAmpere and 1000 picoFarad load. Since this voltage can be displayed in real time (as demonstrated above, using the READ SCHMITT THRESHOLD function) it provides a handy, potentiometer controlled voltage source for a variety of applications.

The Schmitt trigger subsystem has two handshaking signals available. Their use is completely optional and they are referenced to logic ground. All Schmitt trigger handshaking protocols are identical to those discussed under the binary input subsystem earlier in this chapter.

5.5 Specifications of The Binary Output Subsystem

Binary output is handled by the binary device's binary output subsystem. This system uses high power bus driving devices. You may tristate (float) the entire bus by pulling the ENABLE lines low. These and all other data, handshaking, and control lines are held high by passive internal pull-up resistors to +5Volts. If the tristating feature is not required, you will not have to make any connections to these lines. Note that there are two ENABLE lines for the binary output subsystem, one for each byte. They can be used separately, or tied together to tristate the entire bus.

Full handshaking is available with binary output, if desired. Since all handshaking lines are internally pulled-up to their logical "true" state, you are free to implement as much handshaking as your communication scheme requires. If full handshaking is used with binary output, the following sequence of events (as diagrammed in Fig. 6, next page) will occur with each transmission:

1. External device lets the CLEAR TO SEND line go high.

2. ISAAC puts new data on the 16 data output lines.

3. ISAAC sets both STROBE lines high for 12 microseconds.

4. External device should pull CLEAR TO SEND line low, and acquire the new data from the bus.

5. ISAAC pulls both STROBE lines low.

NOTE If you are using LabSoft to control ISAAC you will not have separate STROBE control for each byte. Both STROBE lines will be brought high or low

together. Therefore, your external device need only be connected to one of the STROBE lines.

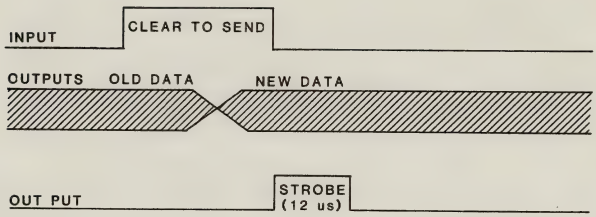

FIGURE 6

Binary output data bus lines are available on the distribution panel and on the following pins of connector E4.

Bit #	Pin #
0	18
1	20
2	22
3	24
4	26
5	28
6	30
7	32
8	36
9	38
10	40
11	42
12	44
13	46
14	48
15	50

The following pins (connector E4) are used by the binary output handshaking and control lines. They are also available, as labeled, on the distribution panel.

Function	Pin #	Direction
Binary Output, STROBE output line, for low order byte (bits #0-#7)	13	output
Binary Output, STROBE output line, for high order byte (bits #8-#15)	14	output
Binary Output, CLEAR TO SEND input line.	10	input
Binary Output, tristate ENABLE, input line for low order byte (bits #0-#7)	16	input

Function	Pin #	Direction
Binary Output, tristate ENABLE, input line, for high order byte (bits #8-#15)	36	input

The specifications for the binary output subsystem are as follows:

Fan out: 12 standard TTL loads, or 50 LS TTL loads.

Output voltage/current: +3.1 Volts/2.6 milliAmperes (output high) +0.5 Volts/20 milliAmperes (output low)

Handshaking Line Fan out: 4 standard TTL loads or 20 LS TTL loads

Each TTL output has a 10 kilOhm resistor to +5 Volts. Binary output enable or disable time from ENABLE input: < 50 nanoseconds.

There are no user configuration options for the binary output device.

5.6 Using the Binary Output Subsystem

There are many potential applications for the binary output subsystem. Everything from simply using the output lines to switch binary peripheral devices on and off, to high speed parallel data communication with complete handshaking can be accommodated by this versatile unit. The outputs (and handshaking and control inputs) are all TTL level lines, referenced to logic ground.

As mentioned in the previous section, all lines have passive pull-ups to +5 Volts. This allows easy interfacing with a wide variety of external devices. Standard (TTL), tristate or open-collector logic can all be accomodated. Since the control and handshaking input lines are also pulled up, (and since their respective functions are all positive true) full, partial, or no handshaking may be used as needed.

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CHAPTER 6

THE COUNTER DEVICE

CHAPTER 6: THE COUNTER DEVICE

ISAAC's Counter Device consists of two functionally unrelated subsystems resident, for hardware design reasons, at the same location. The counter subsystem contains a 16-bit externally clocked count-up counter. A multiplexer on the clock input allows the counter to be clocked from a number of different sources. Normally, the counter is clocked with a TTL level signal, and 7 TTL level inputs are provided by the MUX. The eighth counter input (counter channel 7) is an AC coupled, conditioned input that can accept a variety of input waveforms over a very wide voltage range. The audio subsystem contains an audio beeper and an audio buzzer, which are discrete hardware items operating under software control.

6.1 About Counter Input

The counter subsystem of the counter device provides a means for the Apple II to input a count from an external clock source. This subsystem uses a 16-bit count-up counter. A multiplexer on the clock input allows selection of one of eight clock inputs. The last of these is a special, signal conditioned (level comparator) input that can accept a variety of input waveforms and voltage levels. The other seven are standard TTL level inputs.

The following pins (connector E4) are used by the counter subsystem:

Counter input #	Pin #
0	1
1	3
2	5
3	7
4	2
5	4
6	6
*7	8

* conditioned input channel

TTL logic ground (reference for all counter inputs) on connector E3: pins 32, 34, 36, and 38.

The specifications for the counter input subsystem are as follows:

TTL inputs (channels 0 - 6)

Input voltage/current: +2 Volts/20 microAmperes (input high). +0.8 Volts/ 400 microAmperes (input low).

Maximum count frequency: 10 megaHertz (50% duty cycle).

Minimum count frequency: DC (no limit)

Conditioned input (channel 7)

Sensitivity: 100 milliVolts RMS.

Maximum count frequency: 3 megaHertz. (50% duty cycle).

Minimum count frequency: 0.5 Hertz (sine wave).

Maximum input voltage: 50 Volts, DC + peak AC.

There are no user configuration options for this subsystem.

6.2 Using the Counter Subsystem

This subsystem has a number of uses, most of which involve the counting of events (input to the counter as TTL state-change cycles) or the reading of frequencies (input to counter channel 7, see specifications above). In general, the Counter Device has three functions. The counter can be cleared to zero, enabled to count one of the inputs, or have its value read by LabSoft.

Counter inputs 0 through 6 are standard TTL level inputs. These can be connected to signals from external devices, external prescalers, or external preamplifiers that have TTL compatible output. All of these inputs are referenced to logic ground.

Care must be taken in the driving circuitry and cabling to avoid multiple clocking of the counter. External devices should generate fast risetime edges (Schmitt TTL devices are helpful) and cabling capacitance should be kept to a minimum.

Counter input 7 has a high gain, high speed preamplifier. The input is AC coupled and is designed to measure signals between 0.5 Hertz and 2 megaHertz and amplitudes between 0.1 Volts RMS and 50 Volts (maximum DC + peak AC). Higher-level signals must be attenuated before being connected to the counter input.

6.3 Specifications of The Audio Subsystem

This subsystem contains a beeper and a buzzer for audio alarms. Unlike conventional alarm generation in the Apple II, ISAAC's audio subsystem uses hardware timers to generate the tones. Thus, CPU time is not allocated for tone generation.

There are no I/O connector pins used by the audio subsystem. Audio output (for use with any 8 Ohm extension speaker) is available via a jack located at the left front of the ISAAC main board.

6.4 Using the Audio Subsystem

The audio subsystem can generate either or both of two tones, a high pitch (called "Beep"), and a low pitch (called "Buzz"). Unlike the speaker in the Apple II, these tones can be set to either an on or off state while the computer is free to continue other functions.

LabSoft contains several commands (& BEEP and & BUZZ and their variations) to control the audio subsystem.

The Beep and Buzz functions operate in identical ways. The appropriate sound will occur for 0.1 second plus the amount of time the tone is gated on. Thus, gating the tone on and immediately off again will result in an 0.1 second Buzz or Beep. Because there is no upper limit on how long the tone may be gated on, a tone may be gated on, leaving the computer free to continue processing without being involved in actually generating the

tone. At a later time the computer can gate the tone off, again using very little C.P.U. time. The on/off state of each tone is latched in ISAAC.

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CHAPTER 7

THE TIMER/CLOCK DEVICE

CHAPTER 7: THE TIMER/CLOCK DEVICE

ISAAC's timer/clock device is located on the ISAAC/Apple Interface Card and consists of two functionally unrelated subsystems, the timer subsystem and the real-time clock.

The timer subsystem contains a 16-bit internally clocked timer. Its timing is derived from the host CPU's clock, and is extremely accurate. The 1 MegaHertz CPU clock is divided down to approximately 1 millisecond to 16 seconds - a reasonable range for real-time machine language or high level language access routines. The timer may be read "on the fly"; it does not have to be stopped first.

The real-time clock subsystem consists of a battery backed-up real time clock/calendar. LabSoft provides full command-level software support for this device.

7.1 About Timer Input

The timer can be cleared or read through software. It returns a 16-bit value, each unit representing approximately 1 millisecond. There are no external connections for the timer.

The specifications for the timer subsystem are:

Accuracy: depends on the host CPU's clock crystal.

Resolution: 1 millisecond

The timer does not pause when maximum count is reached, but instead continues from zero.

7.2 Using the Timer Subsystem

The count can be read at any time without stopping the timer. Reading the timer does not affect its overall accuracy, since it does not have to be stopped and restarted (which would add an extra delay). The fastest bit of the timer changes state every 1 millisecond. The timer recycles after 16 seconds.

7.3 About The Real-Time Clock

The real-time clock contains a low power clock circuit, and a battery which will provide power to the unit when system power is turned off. It requires no maintenance other than the initial setting of the clock (LabSoft provides a utility program to do this) and eventual replacement of the the battery.

7.4 Using the Real-Time Clock

All time and date values are input to the Apple via LabSoft commands. The following values are all available in numeric format:

TIME: Hour, Minute, Second

DATE: Year (last two digits), Month, Day of Month, and Day of week (Sunday = 1, Saturday = 7).

There are no real-time clock connections on the I/O connector.

There are no user configuration options for this subsystem, except those dealt with in LabSoft's "SETCLOCK" utility.

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CHAPTER 8

SYSTEM RECONFIGURATION OPTIONS

CHAPTER 8: SYSTEM RECONFIGURATION OPTIONS

The ISAAC/LabSoft/Apple data acquisition system was designed in a way that makes it easy to "customize" the system for specific applications. There are many different ways in which the system hardware may be reconfigured. Some, like changing the power supply or system references, affect the system as a whole. Others affect only specific devices. Adding a resistor divider to one of the analog inputs, for instance, affects only that device.

Most of the reconfiguration options are accomplished by means of DIP switch arrays located, for the most part, on the ISAAC main board. All but a few of the operations discussed in this chapter involve nothing more difficult than setting certain switches to certain positions. Even though it's easy, it's still important to follow the instructions. This is especially true where hardware is involved. Because this machine can be altered in a number of ways, through various means, system reconfiguration should be planned and carried out CAREFULLY!

Some general rules for system reconfiguration are:

A. WRITE IT DOWN: Always keep an accurate record of how the machine is currenty configured. This will make life much easier when the time comes to hook up to other systems, or to reconfigure. For the sake of convenience, especially if you have more than one ISAAC, try taping brief notations of any special reconfigurations to the ISAAC unit's cover.

B. TURN OFF THE POWER: Depending on what kind of changes you are making, and where you are making them, you could have serious problems if there is any power in the system. Be safe - turn off the Apple (and ISAAC if it is powered externally) before making any modifications.

C. USE THE PROPER TOOLS: Flip DIP switches with a ball-point pen or something like it. Claw hammers just won't do. A suitably small screwdriver and some sort of wire strippers are

really all the tools you'll need, at least as far as the ISAAC end of things is concerned.

D. **KNOW YOUR OWN LIMITATIONS:** Limit your hardware modification efforts to ones you're sure fall well within the range of your understanding. If you're not sure, ask someone. If nobody's sure, don't risk it.

If you keep our suggestions in mind when reconfiguring your system, you and ISAAC should live happily ever after. If you disregard us, your relationship (with ISAAC, Cyborg, and probably a few other people) is sure to suffer. Remember that assistance from Cyborg's Technical Support Department requires that you provide us with a full description of any modifications you make. So remember, know what you're doing, and write it down.

All of the possible user reconfiguration options require removing ISAAC's cover. If you're contemplating any reconfiguration, you should first take a good look around the main board and locate the various DIP switch groups referred to in this section.

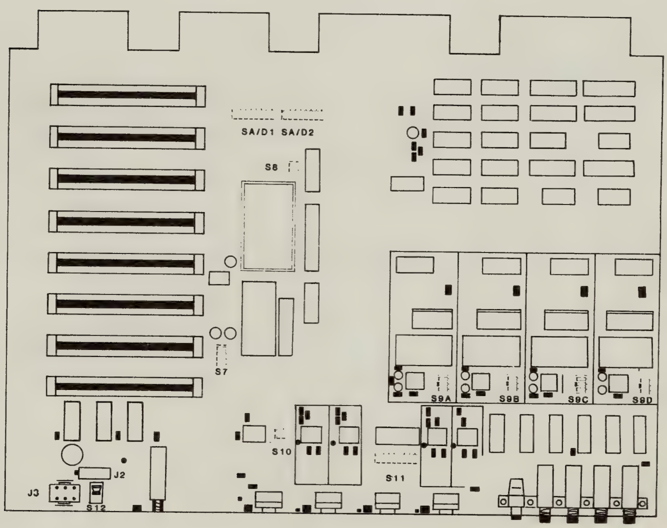


FIGURE 7

8.1 Adding an External Power Supply

One commonly instituted system-level change is the addition of the optional external power supply (Cyborg part #261-031). This allows ISAAC to be powered completely by its own supply, rather than the power supply of the Apple II. If your Apple already contains a number of peripheral cards, it may not have enough power left to properly supply ISAAC.

Exactly when the Apple II begins to suffer from ISAAC's power requirements (or, if you'd rather, when ISAAC begins to suffer from the Apple's power limitations) is a little tricky to determine. Most normal applications, involving an Apple II which contains no more peripheral cards than are necessary to the ISAAC/LabSoft/Apple system, (i.e., printer interface card, disk interface card, and ISAAC/Apple interface card) will not overload the Apple's power supply. As more peripheral cards are added, the environment inside the Apple heats up, (typically after the first four hours or so of operation) and components begin to have problems which generally manifest themselves as program crashes. Powering your ISAAC externally may help alleviate this problem, but keeping your Apple well ventilated (try running it with the cover off) is the best way to avoid heat-induced problems.

In cases where too much is being asked of it, the Apple's power supply just shuts down. This should be taken as a clear indication that it's time to consider powering ISAAC externally.

NOTE As shipped, ISAAC draws the following amounts of power in normal operation.

Supply	Max. Current
+ 5V	1 Amp
+12V	60 mA
-12V	120 mA

The Apple II power supply provides +/-12 Volts which ISAAC uses for all of its analog circuitry. This gives all analog inputs and outputs a maximum effective range of +/-8 Volts. Normally, the range is limited to +/-5 Volts. By adding an external power supply which provides +/-15 Volts, it is

possible (and easy) to change the allowable voltage range on all ISAAC's analog inputs and outputs to +/-10 Volts. If this kind of I/O voltage capability is required by your application, Cyborg's optional power supply will provide the power you need.

The external power supply connector is found on the ISAAC main board, in the left front corner. There is a mating connector with the same pin outs on the end of the external power supply's cord. To install the external supply:

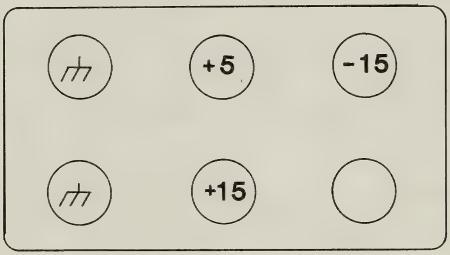
1. Turn off the Apple.

2. Throw switch S12 to EXTERNAL position.

3. Attach the external power supply at connector J6.

NOTE The external power plug will latch in place with an audible click. It will remain positively locked to connector J6 until it is released by applying slight pressure to the sides of the plug as it is pulled out of the connector.

ISAAC power is now separately controlled from its own front panel power switch. If you are going to use an external power supply, we strongly recommend that you use ours (Cyborg part #261-031). If you use any other power supply, it must conform to the requirements of ISAAC's external power connector or you will risk fatal hardware damage. The pin map of the board-mounted power supply connector is shown below.



Any external power supply must provide at least +5 Volts (+/-5%) at 1 Amp and +/-15 Volts (+/-5%) at 150 milliAmperes. Higher voltages will cause significant hardware damage.

8.2 Changing System Voltage References

Changing the voltage references used internally by ISAAC is a system-level reconfiguration affecting all analog inputs and outputs. It is a change you will have to make if you are to take advantage of an added external power supply. In general, the range of any analog input or output can be doubled in this way. To change the voltage references from +/-5 Volts to +/-10 Volts:

1. Connect the optional external power supply, following the instructions in the previous section (8.1).

2. With ISAAC and Apple power turned off, locate the group of DIP switches labelled S10 on the ISAAC main board. Close switch S10/1.

NOTE Unlike the more conventional slide-type DIP switches, the DIP switches used in ISAAC are turned ON ("closed") by pushing down the "ON" side of the switch. They are turned OFF by pushing down the "OFF" side. Every group of DIP switches is labelled on the board, and the individual switches are numbered on the switch housing. When we talk about switch S2/4, we mean switch #4 of switch group S2.

NOTE If this reference voltage change is made without raising the analog supply range to +/-15 Volts (using an external power supply) all kinds of odd voltages will be output by the D/A's. In addition, levels read at any of the analog inputs will yield strange values, particularly around the limits of the signal range.

8.3 Reconfiguring the D/A Subsystem

The output voltage ranges of the four D/A's in this system may be configured individually. In addition, changing the system reference voltages to +/-10 Volts, and the analog power supply to +/-15 Volts, will effectively double any of the ranges selected for these converters. This reconfiguration is accomplished through DIP switch manipulation, according to the table on the next page. (This table relates specifically to S9A, which reconfigures D/A #0, but the procedure is the same, using S9B, S9C, and S9D, for the other three D/A's.)

Output Voltage Range	BIPOLAR S9A/1	Ref Span S9A/2	2x Ref Span S9A/3
0-5 Volts	~~ON~~ off	~~OFF~~ ON	OFF
+/-5 Volts (default)	~~OFF~~ ON	~~ON~~ off	ON
+/-2.5 Volts	ON	~~OFF~~ ON	~~ON~~ off

NOTE These voltage ranges are all doubled if an optional external power supply is connected to ISAAC and the reference set to +/-10 Volts.

Switches S9/2 and S9/3 should never be left in the same (ON or OFF) position.

8.4 Reconfiguring the A/D Subsystem

The entire A/D subsystem's voltage input range (all channels) is switch selectable, using DIP switches S7/1, S7/2, and S7/3. If ISAAC is being powered by the Apple, (and is in its normal internal reference configuration of +/-5 Volts) the following input ranges are available with the following switch positions:

Input Voltage Range	S7/1	S7/2	S7/3
0-5 Volts	OFF	ON	OFF
+/-5 Volts (default)	ON	OFF	ON
+/-2.5 Volts	ON	ON	OFF

Switches S7/2 and S7/3 should never be left in the same (ON or OFF) position.

NOTE These voltage ranges are all doubled if an optional external power supply is connected to ISAAC and the reference set to +/-10 Volts.

8.5 Gain Stage Scaling

There is a gain stage between the analog MUX input device and the A/D converter. In a standard ISAAC this gain is set at unity (no gain). Closing DIP switch S7/4 puts a gain of X10 into effect on all A/D channels. This gain divides any range shown in section 8.4 by 10 (i.e., the +/-5 Volt range becomes a +/-0.5 Volt range).

8.6 Input Dividing

Each A/D input can be divided by a factor of 10 by closing (turning OFF) the DIP switches of groups "S

A/D 1" and "S A/D 2" as shown below:

A/D Channel #	S A/D 1	S A/D 2
0	1	
1	2	
2	3	
3	4	
4	5	
5	6	
6	7	
7	8	
8		1
9		2
10		3
11		4
12		5
13		6
14		7
15		8

NOTE Closing any of these switches expands that A/D channel's range by 10 (i.e, the +/-5 Volt range becomes a +/-50 Volt range). When reconfiguring the A/D subsystem, it is important to understand the various interactions that occur between the operations described in sections 8.4, 8.5, and 8.6.

To ensure safety and long life for both you and ISAAC, keep the signal voltages at ISAAC's inputs low (less than 40 Volts). If higher voltage signals must be measured, they must be divided down and/or isolated externally.

8.7 Reconfiguring for Differential A/D Input

As shipped, ISAAC's A/D inputs are configured to accept up to 16 single-ended (ground referenced) input signals. Closing DIP switch S8-2 reconfigures the A/D MUX to accept up to 8 true differential inputs instead. The principal advantage of true differential input lies in its superior common-mode rejection capability. If your application requires use of common-mode rejection for signal/noise ratio improvement, the reduced number of channels available in the differential configuration will be offset by greatly improved signal quality. Section 4.2 of this manual contains more on using the differential mode.

8.8 Reconfiguring the Schmitt Trigger Subsystem

The maximum comparator input level of all of the Schmitt trigger circuits will always be equal to the system analog reference voltages. Ordinarily these references are set to +/-5 Volts, but an external power supply capable of supplying +/-15 Volts, and an analog reference voltage set for +/-10 Volts will effectively raise the Schmitt input level range to +/-10 Volts.

Although the Schmitt threshold signal can be set using the potentiometer controls on ISAAC's front panel, it may be advantageous to reconfigure each trigger circuit so that it takes its threshold level from an external source instead of from the front panel control. To do this, disconnect potentiometer output from Schmitt threshold input by turning OFF DIP switches at S11 according to the following table.

Schmitt Trigger #	DIP Switch #
0	S11/5
1	S11/6
2	S11/7
3	S11/8

In addition, the Schmitt trigger inputs can be divided by 10 by closing the following DIP switches.

Schmitt Trigger #	DIP Switch #
0	S11/1
1	S11/2
2	S11/3
3	S11/4

NOTE Schmitt threshold voltage must always be in the same range as system analog reference.

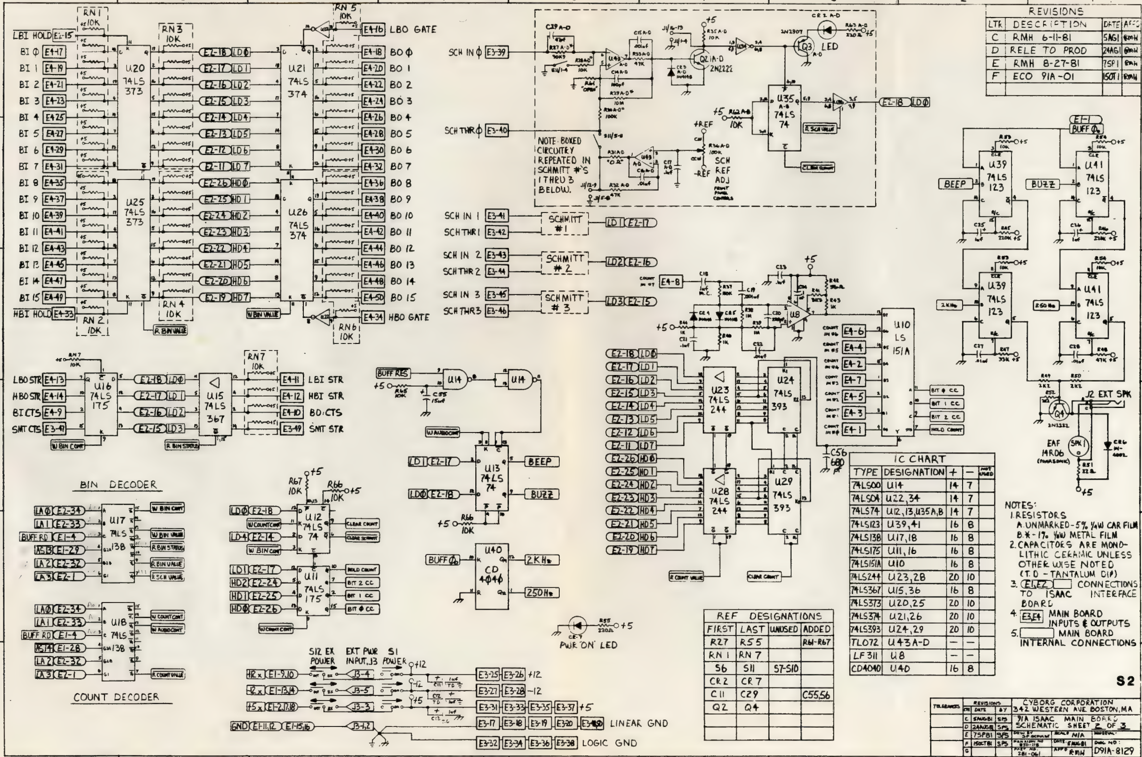
8.9 Adding an External Speaker

There is a jack located on the ISAAC main board which can output ISAAC's Beep and Buzz tones to any speaker with an 8 ohm impedance, for those situations where a very loud alarm tone is needed. Additional amplification will probably be unnecessary.

&&&

APPENDICES

APPENDICES



IC CHART

TYPE	DESIGNATION	+	−	NOT USED
74LS00	U14	14	7	
74LS04	U22,34	14	7	
74LS74	U12,13,U35A,B	14	7	
74LS123	U39,41	16	8	
74LS138	U17,18	16	8	
74LS175	U11,16	16	8	
74LS151A	U10	16	8	
74LS244	U23,28	20	10	
74LS367	U15,36	16	8	
74LS373	U20,25	20	10	
74LS374	U21,26	20	10	
74LS393	U24,29	20	10	
TL072	U43A-D	—	—	
LF311	U8	—	—	
CD4040	U40	16	8	

REF DESIGNATIONS

FIRST	LAST	UNUSED	ADDED
R27	R55		R61-R67
RN1	RN7		
S6	S11	S7-S10	
CR2	CR7		
C11	C29		C55,56
Q2	Q4		

REVISIONS

LTR	DESCRIPTION	DATE	APP'D
C	RMH 6-11-81	5AG1	RMH
D	RELE TO PROD	24AG1	RMH
E	RMH 8-27-81	7SP1	RMH
F	ECO 91A-01	15OT1	RMH

NOTES:
1. RESISTORS
   A. UNMARKED - 5% 1/4W CAR FILM
   B. * - 1% 1/4W METAL FILM
2. CAPACITORS ARE MONOLITHIC CERAMIC UNLESS OTHERWISE NOTED (T.D - TANTALUM DIP)
3. (E1, E2) CONNECTIONS TO ISAAC INTERFACE BOARD
4. [E3, E4] MAIN BOARD INPUTS & OUTPUTS
5. [ ] MAIN BOARD INTERNAL CONNECTIONS

S2

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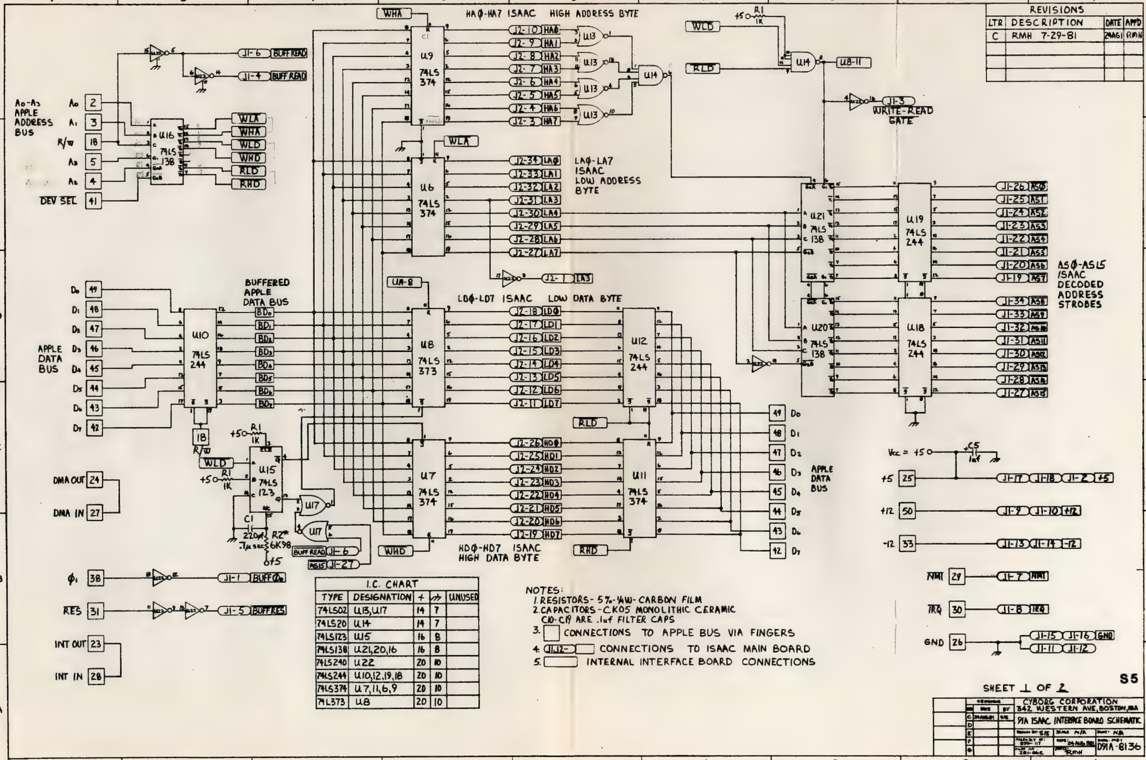
91A ISAAC MAIN BOARD SCHEMATIC SHEET 2 OF 3

DWG NO: D91A-8129



REVISIONS			
LTR	DESCRIPTION	DATE	APP'D
C	RMH 7-29-81	24AUG81	RMH

I.C. CHART

TYPE	DESIGNATION	+	⏚	UNUSED
74LS02	U13,U17	14	7	
74LS20	U14	14	7	
74LS123	U15	16	8	
74LS138	U21,20,16	16	8	
74LS240	U22	20	10	
74LS244	U10,12,19,18	20	10	
74LS374	U7,11,6,9	20	10	
74L373	U8	20	10	

NOTES:
1. RESISTORS - 5% - 1/4W - CARBON FILM
2. CAPACITORS - CK05 MONOLITHIC CERAMIC
C10-C19 ARE .1uf FILTER CAPS
3. ☐ CONNECTIONS TO APPLE BUS VIA FINGERS
4. (J1,J2- ☐ CONNECTIONS TO ISAAC MAIN BOARD
5. ☐ INTERNAL INTERFACE BOARD CONNECTIONS

S5

SHEET 1 OF 2

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91A ISAAC INTERFACE BOARD SCHEMATIC
D91A-8136

APPENDIX A: I/O Connector Pinouts

This appendix will be of interest primarily to those who are hard-wiring ISAAC into some application setup, using mass terminated interfacing cable (Cyborg part #800-059). All of these pinouts are available (and labeled) on the standard distribution panel. The two 50-pin I/O connectors, (E3 and E4) are located on the back of ISAAC's chassis.

NOTE > indicates an OUTPUT HANDSHAKING line; < indicates an INPUT HANDSHAKING line.

Connector E4

Pin #		Function
1		Counter input (TTL) #0
2		" " " #4
3		" " " #1
4		" " " #5
5		" " " #2
6		" " " #6
7		" " " #3
8		" " (analog) #7
9	>	Binary input CLEAR TO SEND
10	<	Binary output CLEAR TO SEND
11	<	Binary Input, low byte, STROBE
12	<	Binary Input, high byte, STROBE
13	>	Binary Output, low byte, STROBE
14	>	" " high byte "
15	<	Binary Input, low byte, HOLD
16	<	Binary Output, low byte, tristate ENABLE
17		Binary Input data line #0
18		Binary output data line #0
19		" input " " #1
20		" output " " #1
21		" input " " #2
22		" output " " #2
23		" in " " #3
24		" out " " #3
25		" in " " #4
26		" out " " #4
27		" in " " #5
28		" out " " #5
29		" in " " #6

30		"	out	"	"	#6
31		"	in	"	"	#7
32		"	out	"	"	#7
33	<	Binary Input, high byte, HOLD				
34	<	Binary Output,high byte, tristate ENABLE				
35		Binary	input	data	line	#8
36		Binary	output	data	line	#8
37		"	input	"	"	#9
38		"	output	"	"	#9
39		"	input	"	"	#10
40		"	output	"	"	#10
41		Binary	input	data	line	#11
42		"	output	"	"	#11
43		"	input	"	"	#12
44		"	output	"	"	#12
45		"	input	"	"	#13
46		"	~~in~~ out	"	"	#13
47		"	~~out~~ in	"	"	#14
48		"	~~in~~ out	"	"	#14
49		"	~~out~~ in	"	"	#15
50		"	~~in~~ out	"	"	#15

Connector E3

Pin #	Function
1	A/D input channel 0
2	" " " 8
3	" " " 1
4	" " " 9
5	" " " 2
6	" " " 10
7	" " " 3
8	" " " 11
9	" " " 4
10	" " " 12
11	" " " 5
12	" " " 13
13	" " " 6
14	" " " 14
15	" " " 7
16	" " " 15
17	analog ground
18	" "
19	" "
20	" "
21	D/A out channel 0
22	" " " 2
23	" " " 1
24	" " " 3

25		+12 Volts
26		+12 Volts
27		-12 Volts
28		-12 Volts
29		+Reference Voltage
30		-Reference Voltage
31		+5 Volts
32		TTL logic ground
33		+5 Volts
34		TTL logic ground
35		+5 Volts
36		TTL logic ground
37		+5 Volts
38		TTL logic ground
39		Schmitt input 0
40		Schmitt threshold 0
41		Schmitt input 1
42		Schmitt threshold 1
43		Schmitt input 2
44		Schmitt threshold 2
45		Schmitt input 3
46		Schmitt threshold 3
47	<	Schmitt Clear-To-Send
48		analog ground
49	>	Schmitt Strobe
50		analog ground

&&&

APPENDIX X: Hardware Expansion

You may have noticed that the ISAAC main board has eight edge connector "slots" similar to those used in the Apple II for peripheral expansion. These slots are intended to expand the functional capabilities of the basic ISAAC unit. There are two principal reasons for hardware expansion. The first is to enhance, via either front end or back end processing, the inputs and outputs of existing devices or subsystems. The second is to add new devices.

WARNING! DO NOT PLUG ANY APPLE PERIPHERAL CARD INTO ANY ISAAC EXPANSION SLOT. THE PINOUTS ARE INCOMPATIBLE AND FATAL HARDWARE DAMAGE WILL OCCUR!

X.1 Enhancement of Existing Devices

As presently configured, ISAAC is capable of certain I/O operations within certain specified ranges. These are perfectly adequate for using ISAAC to perform a wide variety of data acquisition and control functions. Eventually, though, anyone can run up against an incoming signal that requires preamplification, attenuation, or some other type of front-end processing.

For example, an analog input signal in the range of 0-1 milliVolts could not be handled by ISAAC's analog input subsystem. To allow the system to deal with this low level signal, the signal would first have to be amplified. This could, of course, be done externally, but it would certainly be more convenient to have the pre-amp as part of the system, on a card installed in one of ISAAC's expansion device slots. If you have the skills, it will be easy to construct a small pre-amplifier on an Apple prototyping card (Cyborg part #800-022) and install it in an ISAAC Expansion Slot. These slots provide the power, grounds, and reference voltages required, and also contain inputs and outputs to different ISAAC devices. There is an expansion slot pin-out table included in the schematics found at the end of this manual.

Each slot can contain a simple pre- or post-processor for I/O signals, or a more complex device. Some interesting possibilities for simple processors are:

- Analog pre-amplifier.
- Analog output amplifier.
- Input signal filter
- High frequency counter pre-scaler.
- Frequency counter with internal timer input.
- Thermocouple input.
- Relay output.
- Isolated input or output.

More complex processors might include:

- Analog input with programmable filtering.
- Analog pre-amp with programmable gain.
- Analog output amp with programmable gain.
- Analog sum, difference, or multiplier.
- Frequency to analog converter.
- Analog sub-multiplexer.
- Programmable oscillator

NOTE Since ISAAC contains a great deal of high frequency digital circuitry, care must be taken when attempting to bring low-level signals into the unit for pre-processing. Low level analog signals must be shielded, even within the confines of ISAAC's chassis. For some applications, external devices may be more suitable.

X.2 Other Expansion Devices

As the ISAAC device map (see Section X.4 of this appendix) indicates, there are a number of expansion devices which ISAAC has been configured to accept, but which have not been included on the ISAAC main board. Each category of device has its appropriate expansion slot. It should be a simple matter fo a person with the requisite skills to build a specific device and install it in one of these slots. LabSoft comes equipped with two expansion commands, suitable for accessing any legal ISAAC expansion device. These commands, (& RDEV and & WRDEV and their matrix counterparts) are covered in the <u>LabSoft Reference Manual</u>.

X.3 I/O Signal Routing

When constructing expansion devices, you should be aware that I/O signals are routed more or less directly from one of the I/O connectors to certain pins in the expansion slots. The following table details signal routing, and is applicable to any ISAAC expansion slot.

{For Slot #n}

Slot Pin #	I/O Pin #	Function
24	E4, 1,2,3,4,5,6,7	TTL Counter Input (slots 0 to 6 only)
27	E3 1,3,5,7,9,11,13,15	A/D channel #n.
28	E3, 0,2,4,6,8,10,12,14	A/D channel #(n+8)
32	E3, 21,22,23,24	D/A channel #n. (slots 0 to 3 only)

These duplicate connections permit, for example, an expansion card in slot #3 to be directly connected to counter input #3. Note that the duplicate pin on the rear connector (E3 or E4) cannot be used while such an expansion card is installed.

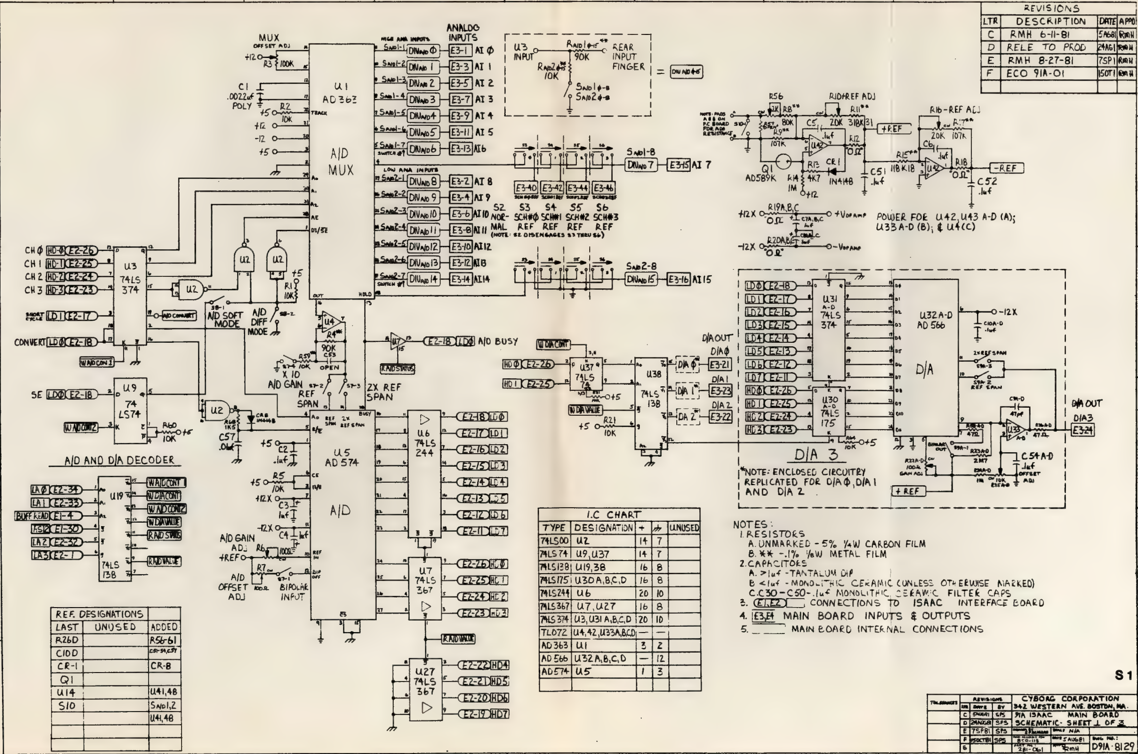
X.4 ISAAC 91A Hardware Device Map

DEVICE #	DEVICE TYPE
0	EXPANSION DEVICE # 0
1	EXPANSION DEVICE # 1
2	EXPANSION DEVICE # 2
3	EXPANSION DEVICE # 3
4	EXPANSION DEVICE # 4
5	EXPANSION DEVICE # 5
6	EXPANSION DEVICE # 6
7	EXPANSION DEVICE # 7
8	NON-IMPLEMENTED DEVICE
9	NON-IMPLEMENTED DEVICE
10	NON-IMPLEMENTED DEVICE
11	NON-IMPLEMENTED DEVICE
12	DEFAULT ANALOG I/O
13	DEFAULT BINARY I/O
14	DEFAULT COUNTER
15	DEFAULT TIMER/CLOCK

FIGURE 8

&&&

APPENDIX I: Index



REVISIONS

LTR	DESCRIPTION	DATE	APPD
C	RMH 6-11-81	5AG81	RMH
D	RELE TO PROD	24AG1	RMH
E	RMH 8-27-81	7SP1	RMH
F	ECO 91A-01	15OT1	RMH

I.C CHART

TYPE	DESIGNATION	+	⏚	UNUSED
74LS00	U2	14	7	
74LS74	U9, U37	14	7	
74LS138	U19, 38	16	8	
74LS175	U30A,B,C,D	16	8	
74LS244	U6	20	10	
74LS367	U7, U27	16	8	
74LS374	U3, U31 A,B,C,D	20	10	
TL072	U4,42,U33A,B,C,D	—	—	
AD363	U1	3	2	
AD566	U32A,B,C,D	—	12	
AD574	U5	1	3	

REF. DESIGNATIONS

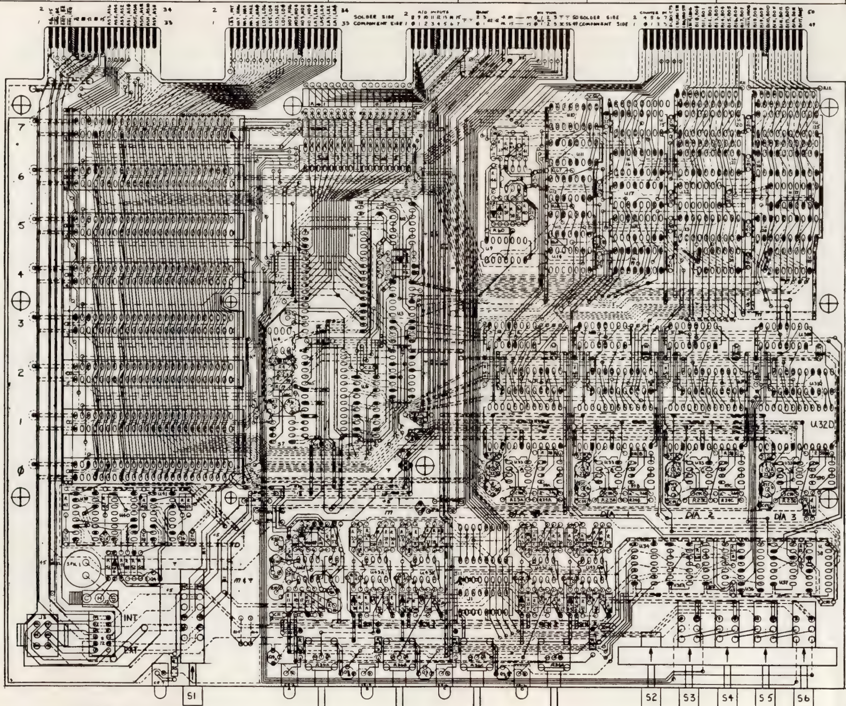
LAST	UNUSED	ADDED
R26D		R56-61
C100		C51-54, C57
CR-1		CR-8
Q1		
U14		U41, 48
S10		SNO1,2
		U41, 48

NOTES:
1. RESISTORS
   A. UNMARKED - 5% 1/4W CARBON FILM
   B. ** - .1% 1/8W METAL FILM
2. CAPACITORS
   A. >1uf - TANTALUM DIP
   B <1uf - MONOLITHIC CERAMIC (UNLESS OTHERWISE MARKED)
   C. C30 - C50 - .1uf MONOLITHIC CERAMIC FILTER CAPS
3. (E1,E2) CONNECTIONS TO ISAAC INTERFACE BOARD
4. [E3,E4] MAIN BOARD INPUTS & OUTPUTS
5. ______ MAIN BOARD INTERNAL CONNECTIONS

S1

TOLERANCES	REVISIONS			CYBORG CORPORATION 342 WESTERN AVE. BOSTON, MA.		
	LTR	DATE	BY			
	C	5AUG81	SPS	91A ISAAC MAIN BOARD SCHEMATIC - SHEET 1 OF 3		
	D	24AUG81	SPS			
	E	7SEP81	SPS		SCALE N/A	
	F	15OCT81	SPS	850-118	DATE 5AUG81	DWG NO.: D91A-8129
	G			PART NO. 281-061	RMH	

REVISIONS			
LTR	DESCRIPTION	DATE	APP
C	RMH 6-11-81	4AUG81	RMH
D	RELE TO PROD	21AUG81	RMH
E	RMH 8-27-81	7SEP81	RMH
F	ECO 91A-01	23OCT81	RMH



COMPONENT SIDE

NOTE:
1. SOLID FOIL PATHS ON COMPONENT SIDE
2. DOTTED FOIL PATHS ON SOLDER SIDE

S4

REVISIONS		
LTR	DATE	BY
C	4AUG81	SPS
D	21AUG81	SPS
E	7SEP81	SPS
F	23OCT81	SPS
G		

CYBORG CORPORATION
342 WESTERN AVE BOSTON, MA

91A ISAAC MAIN BOARD LAYOUT

SPS	2 TO 1	
850-110	4 AUG 81	
281-9??	RMH	D91A-8130

REVISIONS			
LTR	DESCRIPTION	DATE	APPD
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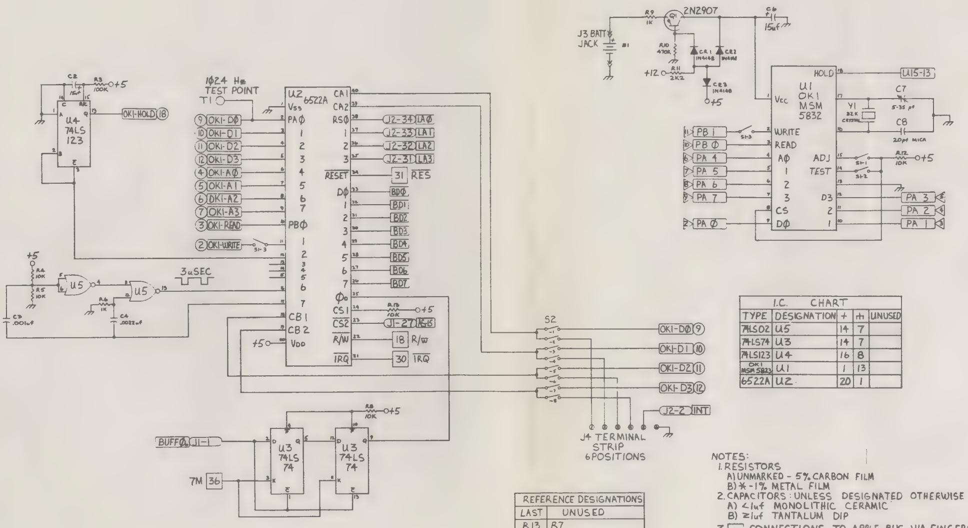


I.C. CHART				
TYPE	DESIGNATION	+	⏚	UNUSED
74LS02	U5	14	7	
74LS74	U3	14	7	
74LS123	U4	16	8	
OKI MSM 5832	U1	1	13	
6522A	U2	20	1	

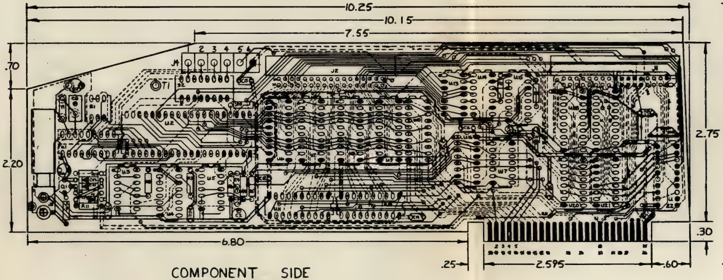
REFERENCE DESIGNATIONS	
LAST	UNUSED
R13	R7
C19	C9
S2	
J4	
U22	
Q1	
CR3	
Y1	

NOTES:
1. RESISTORS
   A) UNMARKED - 5% CARBON FILM
   B) * -1% METAL FILM
2. CAPACITORS: UNLESS DESIGNATED OTHERWISE
   A) <1uf MONOLITHIC CERAMIC
   B) ≥1uf TANTALUM DIP
3. ▭ CONNECTIONS TO APPLE BUS VIA FINGERS
4. (J1,J2▭▭ CONNECTIONS TO ISAAC MAIN BOARD
5. ▭ INTERNAL CONNECTIONS
6. (9) OKI PIN NUMBERS
7. ▷ 6522A PIN NUMBERS

S6

CYBORG CORPORATION
342 WESTERN AVE BOSTON, MA
91A ISAAC INTERFACE SCHEMATIC
SHEET 2 OF 2
SCALE N/A
DRAWING NO. D91A-8136

REVISIONS			
LTR	DESCRIPTION	DATE	APPD
B	RMH 8-12-81	29AG81	RMH
C	RELE TO PROD	17SP81	RMH



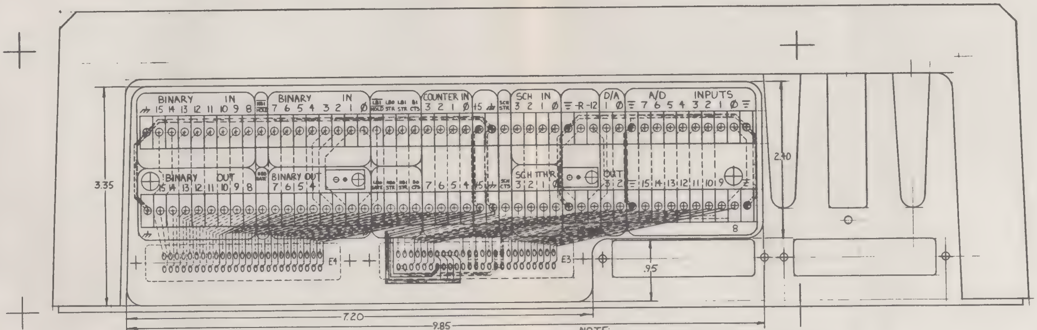
COMPONENT SIDE

NOTE:
1. SOLID FOIL PATHS ON COMPONENT SIDE.
2. DOTTED FOIL PATHS ON SOLDER SIDE

S7

B	29AG81	SPS	CYBORG CORPORATION 342 WESTERN AVE. BOSTON, MA
C	17SP81	SPS	91A ISAAC INTERFACE LAYOUT
D			SPS · 2 TO 1
E			29AUG81 · D91A-B137
F			RMH

REVISIONS			
LTR	DESCRIPTION	DATE	APPD
B	RELE TO PROD	10SP81	RMH
C	CORR & ADD	28SP81	RMH



COMPONENT SIDE

NOTE:
1. SOLID FOIL PATHS ON COMPONENT SIDE
2. DOTTED FOIL PATHS ON SOLDER SIDE

E4

COMPONENT SIDE	49	47	45	43	41	39	37	35	33	31	29	27	25	23	21	19	17	15	13	11	9	7	5	3	1
	15	14	13	12	11	10	9	8	MBI HOLD	7	6	5	4	3	2	1	Ø	LBI HOLD	LBO STR	LBI STR	BI CTS	3	2	1	Ø
	15	14	13	12	11	10	9	8	MBO GATE	7	6	5	4	3	2	1	Ø	LBO GATE	MBO STR	MBI STR	BO CTS	7	6	5	4
SOLDER SIDE	50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2

E3

COMPONENT SIDE	49	47	45	43	41	39	37	35	33	31	29	27	25	23	21	19	17	15	13	11	9	7	5	3	1
	SCH STR	SCH CTS	3	2	1	Ø	+5	+5	+5	+5	+R	-12	+12	1	Ø	⏚	⏚	7	6	5	4	3	2	1	Ø
	⏚	⏚	3	2	1	Ø	⏚	⏚	⏚	⏚	-R	-12	+12	3	2	⏚	⏚	15	14	13	12	11	10	9	8
SOLDER SIDE	50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2

S8

REVISIONS			CYBORG CORPORATION 342 WESTERN AVE. BOSTON, MA		
LTR	DATE	BY	91A ISAAC DISTRIBUTION BOARD - LAYOUT		
A					
B	10SEP81	SPS			
C	28SEP81	SPS	DRAWN BY SPS	SCALE 2 TO 1	
D			ASSEMBLY NO. 880-10	DATE 10 SEP81	DRAWING NO. D91A-8149
E			PART NO. 281-063	APP'D RMH	

NOTES

ISAAC NOTES

Hardware Reference Manual

Cyborg

ISAAC

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